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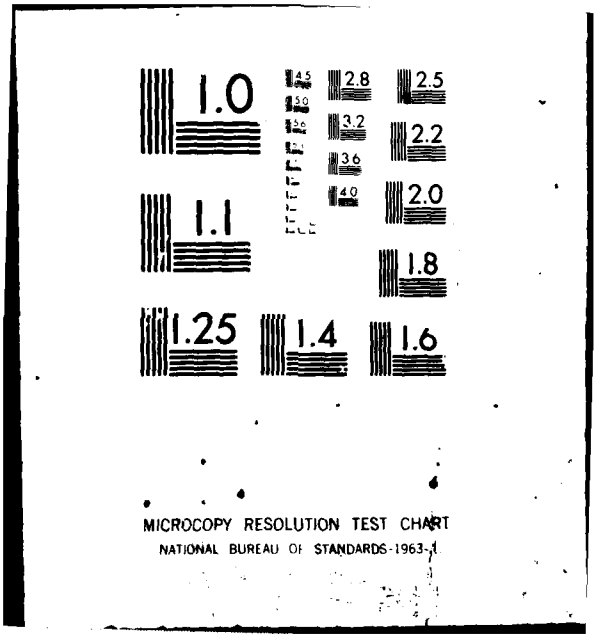
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# FOREIGN TECHNOLOGY DIVISION

AN AMATEUR SATELLITE TRACKING
(IN THE PRC)

by

Zhi Wang

# EDITED TRANSLATION

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# AN AMATEUR SATELLITE TRACKING TEAM (in the PRC)

Zhi Wang

This article concerns amateur activities of students of science and technology. After participating in amateur satellite tracing activities, the students learned a great deal about astronomy mathematics, wireless telegraphy, meteorology, etc. What they learned added to the knowledge they already had and gave them a broader view of advanced technology. This kind of avocational activity should be encouraged.

* * * * * * * *

60 or 70 excited English boys rushed into the classroom to hear the announcement of the launching of a manned "flying ship" by the Soviet Union, the "Alliance". Pei Li, their physics teacher, had already told them that as soon as the new flying ship "Alliance" was launched, it would dock with the space station, the "Gun Salute". The boys were surprised that the time difference was only 12 seconds between the actual launching time and [redacted] Pei Li's prediction. Even before Tass reported the event, Pei Li knew, as he had on previous occasions, about the space launching. When the space station Gun Salute No. 3 was launched by the Soviet Union in July, 1974, [redacted] Pei Li correctly predicted that the space station would fly over the launching site at Qiu La Tan of central Asia in the Soviet Union in early July and that the space ship Alliance would be launched to dock with this space station. The Soviet Union usually waits some time before reporting a successful space launching so that any mishap will not be known to the public.

Aware of this policy, foreign correspondents in Moscow insistently questioned high space officials of the Soviet Union forcing

them to admit that a manned space ship was about to be launched. The boys listened with deep interest to the story of the joint flight of Gun Salute 6 and Alliance 27. They also heard that the astronauts complained to the staff members of the ground station "Daybreak" in the Crimea about having to get up so early.

These are some of the activities of the avocational space tracing team at Kay Te Lin School, 160 miles north of London, led by Pei Li.

CULTIVATION OF INTEREST

Pei Li is 51 years old. After graduation from college he became a physics teacher at Kay Te Lin School and now has been teaching physics there for 25 years. How did he become interested in satellite tracking? In 1957, the Soviet Union launched the first man-made earth satellite but Pei Li did not get to see it. One month later, he took a picture of the second man-made earth satellite and was excited when he discovered in the negative the line of flight of the satellite. A year later he saw it exhibited in the Brussels Universal and International Exposition. He also chanced to know a teacher at another school who recorded the signals from the first Soviet Union's man-made earth satellite and learned that all the signals had the characteristics of the Doppler frequency shift. These things stirred up in Pei Li a strong desire to trace satellites. He and Si Lei Te, a new chemistry teacher and an amateur radio buff, agreed that they would record the signals transmitted in flight from satellites. The Soviet Union launched a third man-made earth satellite but Pei Li and Si Lei Te did not know how many months this satellite's signals would be transmitted and they did not track it. They waited and waited for the launching of the fourth satellite and at four o-clock early one morning, Pei Li and Si Lei Te recorded the signals of the fourth satellite as it passed over the school. The success of this tracking encouraged them to continue observations and recordings of the various satellites' "reliabilities". Pei Li acts on the principle that it is more productive to get students involved in mathematics,

astronomy, wireless telegraph, meteorology and other sciences rather than force these subjects upon them directly. Instead he chooses a guiding method. He groups the students into several small teams and shows them how to take pictures of reconnaissance satellites, communication satellites, warning satellites, marine satellites and interception satellites. After a certain time they all took their turn. Also, he let the students help in collecting the meteorological data, the data of the solar ray angles, etc., so that they could develop their knowledge. In this way, the satellite tracking has become a preferred subject of the teachers and students of the Kai Te Lin team.

WORLD FAME

For many years, the Kai Te Lin team generated much headline news about the space activities and information of its own. One time even a government intelligence organization with excessive funds became a world famous space tracking group. Pei Li was then the smartest person in the group and received an "Imperial Medal" of England. He was honored as a "World Specialist". A booklet, The Space Program in the Soviet Union, 1971-1975, published by the U. S. Congress, includes literature by Pei Li. The following are some of the examples of aircraft trackings by the Kay Te Lin team.

In 1962, the Kai Te Lin team discovered the Soviet Union satellite, "Universe 5", was sending out signals using an unusual method. Through analysis, they found out that the electric voltage of the satellite solar battery dropped as the satellite rotated when the battery was on the side of the satellite away from the sun. The radio frequency transmitted from the satellite was subjected to frequency shift. They had already tracked the U. S. satellite, "Discoverer 36", one of the 38 reconnaissance satellites the United States launched in the early stages of the space program.

Through ~~the~~ observations the Kai Te Li team discovered that the rotation periods of satellites decrease slowly. On the basis of the

data obtained from observing several satellites before Discoverer, they successfully predicted the date for Discoverer 36's reentering the earth's atmosphere. In 1962, using a magnetic tape recorder, they recorded a conversation between two astronauts in spaceships "Eastern 3" and "Eastern 4" for the first time. It could have been useful later on but it is regretable that the recording of the conversation of such historical significance was erased. The following year they watched the space flight of a woman astronaut nicknamed "Sea Gull", an astute, knowledgable and pretty woman. In 1964, during the first orbit after the manned spaceship "Uprising" was launched, the Kai Te Lin team received the signals from the satellite and even before the official announ c ement by the Soviet Union was made, they gave the information to a radio station and a space research center. But the reply they received from them was: "You are wrong". This did not affect their enthusiasm a bit and they continued tracking the Soviet Union's space flights.

FINDING A SECRET SPACE LAUNCHING SITE

Around Christmas, 1966, 65 newspaper reporters and four TV reporters rushed to Kai Te Lin School asking Pei Li how he and his team discovered the secret Soviet Union launching site at "Pu Lie Xie Ci Ke". Already on March 17, 1966, the Soviet Union launched a satellite "Universe 112" and the Kai Te Lin team received signals from the satellite during the second and third orbits and for two more days after that. And they discovered there were some differences between this particular satellite and others:

1. The angle of inclination of the satellite was 72.1 degrees which is rather large. This fact would explain that it possibly used a "high thrust rocket" or it was possibly launched from a new launch site at a comparatively high latitude.

2. The launching time was 10:15, Grennwich Standard Time. Supposing that this satellite was launched at Qiu La Tan launching site, which is located at $63^{\circ}20'$ east, $45^{\circ}18'$ north and in a zone with a five-hour time difference from GST, the local time of the launch must have been 3:50 pm. Usually, most of the satellites were

launched at Qiu La Tan either at 11:00 am or 2:00 pm local time; 3:50 pm was clearly too late as the launching hour.

3. Every day, during the 5th and 6th orbits of the satellite flight, the Kai Te Lin team could not obtain signals from the satellite. The signals received at other times were weak in intensity and, furthermore, the duration of the signals was short. This explained that when the satellite flew over points further north, it transmitted signals by command from a ground station. The frequency of the signals also changed from useful 19.995 million cycles to 19.990 million cycles.

4. The duration of one travel cycle of the satellite was 92.8 minutes long. The longitude difference of the ground track formed by the bottom of two successive orbitings of the satellite was $23.24^{\circ}$. It was noticed that when the satellite revolved around the earth 31 times, the longitude difference at the perigee of the satellite was 31 times $23.24^{\circ}$. This comes to $719.44^{\circ}$, roughly $720^{\circ}$, which equals two revolutions around the earth. This explains that the perigee of the satellite repeats once every 31 revolutions. In case the launch site was Qiu La Tan near the Salten Sea of the Soviet Union and the landing site was in its vicinity, the satellite should land for a revolution number equal to 31 multiplied by an integral number. If a satellite is eight days old in space, the best landing time would be during the 124th revolution. However, the Royal Aeronautic Research Centre of England announced that the actual life span of the satellite was 7.79 days. When the satellite cycle period was divided by this number, in actuality, the satellite lands during the 112th revolution and 112 is not a whole multiple of 31. The Kai Te Lin team surmised the possibilities of a launch site change or landing site change. They thought that the Soviet Union was using a new launch site, with the approximate location $71^{\circ}$ north and $52^{\circ}$ east. They wrote a letter to "Aviation" magazine. The magazine printed the letter but this new discovery by the team did not attract people's attention.

During the next half year, the Soviet Union launched several satellites with a $73^{\circ}$ angle of inclination. Particularly, the time

Universe 127 (129 ?) was launched on October 14, 1966, was 12 noon GST which corresponds to 5:00 pm Qui La Tan time. The frequency of the signals was 19.990 million cycles and it was under the control of a northern ground station and it landed after 6.75 days of flight. Its angle of inclination was only 64.57°. The Kai Te Lin team figured this out by comparing the initial position of this satellite and the initial position of satellite No. 112. From the result of this comparison, they discovered two lines of the initial locus intersected at 63° north and 41° east, which is the location of Pu Lie Xie Ci Ke. The Kai Te Lin team again wrote a letter to "Aviation" magazine and also announced their discovery to the "English Interstellar Aviation Association". Aviation magazine did not handle the letter for two years before they finally published it. But not much public attention was paid to the letter.

Up to the end of the year, more and more facts and information proved that the Soviet Union was definitely using a new secret launch site and people began to recognize the significance of the findings by the Kai Te Lin team. Aviation magazine and the Intersteller Aviation Association sent them a radio receiver as a gift. Later, the United States published a satellite photo of this launch site. The statistics show that almost all the satellites launched every year at Pu Lie Xie Ci Ke are for military purposes and amount to 50% of all the satellites launched every year throughout the world. It is the most "busy and flourishing" launch site in the world but the Soviet Union has never admitted the existence of this launch site.

## DILIGENT AND LABORIOUS OBSERVATIONS

The Kai Te Lin Team has made many remarkable achievements but certainly some people may think of the team in this way: "No doubt they have high quality telescopes for astronomical observations and huge radars, sophisticated computers and many expensive precision instruments...". However, as you walk into the physics lab on the first floor of Kai Te Lin School, you only can see the usual radio

receivers, magnetic tape recorders and an open book cabinet for the observation data files. They were quite "poor" in the past and they are not "rich" now. And yet, they firmly kept doing observations for 10 years. Conscientious about details, they collected numerical data and they did repeated calculations and analyses. And by hard work they made up for the lack of ~~the~~ instruments of quality and quantity.

The Kai Te Lin team classified various types of satellites on the basis of the locus of the satellite path, the characteristics of the radio signals, etc., and they created a set of "Kai Te Lin methods". These methods are used today by the amateur satellite trackers all over the world and some of the methods are:

1. Visual eye-measurement. They use very simple binoculars and even make naked-eye observations of the satellites in the early morning or before dark. For example, about 9:00 pm, May 13, 1966, they observed that the intensity of the satellite Universe 117 was a straight continuous +2 magnitude but the illumination of its "launch rocket", on the other hand, was between +2 and +5 magnitudes. (The magnitude of the star increases as the star comes closer to the earth. The magnitude of the best known star, Vega, is +0.04 and that of the brightest star, Sirius, is -1.43. Most human eyes can observe a star with +6 magnitude). The frequency changes once every second.

This was explained by the fact that the satellite was in a stable attitude whereas the rocket was rolling incessantly. They also observed that the illumination intensity of Universe 605 was +0.05 magnitude, ~~and~~ showing the satellite was very big. There existed the possibility that the spaceship Alliance was unmanned or, instead, was made for a test animal.

2. Analysis of the orbital path. For example, on the basis of the ground track of the satellite Universe 113, they discovered that the ground track of the 118th orbit on the 8th day of flight and the ground track of the 7th orbiting on the first day were on the top of another. This showed that the satellite can cover the entire

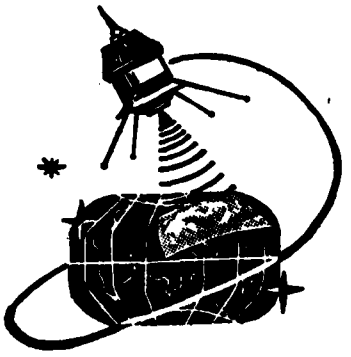
United States within eight days. This is the reason why the Soviet Union designed its first photo reconnaissance satellite with an eight-day life span to accomplish the mission. Also, the team derived a formula to calculate the travel cycle of a satellite with an "inflexible orbit".

Depending upon the altitude of the satellite, meteorological conditions of a certain region, and the angle of the solar rays, they could explain whether or not a certain satellite could do photo reconnaissance activities as it flew over a specific region.

3. Analysis of radio signals. The Kai Te Lin team analyzed various flexible orbit and inflexible orbit photo reconnaissance satellites of the Soviet Union on the basis of the frequency of the telemetered signals the satellites sent to the ground station and their "encoding" system. Abrupt changes in the frequency of transmitted signals by a satellite meant that another just launched satellite took over the same frequency. According to this rule, every time a satellite in the sky changed the frequency of its signals, the team was able to predict that the Soviet Union was about to launch a new satellite. As the landing parachute of a photo reconnaissance satellite was opening, they observed that a "visual signal" was sent out so that the landing ground crew could locate the satellite. Seven or eight minutes later, the intensity of the "visual signal" suddenly dropped and this indicated the landing ship had landed. At the time of landing, the "visual signal machine" continued operating for a period of time and the duration of this operating time gave them the accuracy of the landing operation. If the length of the time was long, it meant that the landing ship landed a distance away from the specified landing area and the landing ground crew had to have time to get to the landing ship and shut off the "visual signal machine". If the intensity of the visual signal was unchanged from the beginning during the entire descent and suddenly stopped before seven minutes, this meant that an airplane might have recovered the landing ship in the air. During the Indo-Pakistani War, depending upon the radio signals from a satellite, they discovered that a Soviet reconnaissance satellite took photos of the war zone

with a very high speed camera, compared to peace time missions. They also achieved a break-through by obtaining the breathing data of an astronaut in a manned spaceship of the Soviet Union and they telemetered the pressure changes inside the satellite, etc.

4. Cooperation from abroad. Besides the Kai Te Lin team, there are numerous amateur space trackers in the world. Mr. Ge La Han of Stockholm, Sweden, is one of them. His geographical location makes it easy to receive powerful and high frequency signals which are difficult to receive in England. Mr. Fu Lai Ge of Florida in the United States is a professor of x-ray astronomy who organized more than 20 people into a group of amateur satellite trackers called "Isle of Cyprus". They have an x-ray telescope in Pa Lin Island and it is quite easy to get "visual signals" of various aircraft that land as they are scheduled in the grassland of Ha Sa Ke Si Tan. On Fiji, a remote relative of Pei Li has joined the amateur satellite tracking troup...All of them want to exchange information and cooperate with the Kai Te Lin team. The Kai Te Lin team is growing and it is big now.



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